
IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Keil et al.

Attorney Docket No.:

LAM1P175/P1148

Application No.: 10/600,191

Examiner: Arancibia, Maureen G.

Filed: June 20, 2003

Group: 1763

Title: MAGNETIC ENHANCEMENT FOR
MECHANICAL CONFINEMENT OF PLASMA

Confirmation: 8804

Commissioner for Patents
Washington, D.C. 20231

DECLARATION OF DOUGLAS L. KEIL UNDER 37 C.F.R. § 1.132

Sir:

I, Douglas L. Keil, declare as follows:

1. I am a co-inventor in the above identified patent application.
2. I am a citizen of the United States of America.
3. I received a Ph.D degree from the University of Wisconsin Madison, in Madison, Wisconsin.
4. I have worked for Lam Research Corporation since January of 1997 doing research and new process development on semiconductor device fabrication and plasma dry etch systems.
5. I am familiar with the Office Action from the United States Patent and Trademark Office mailed July 25, 2007, in the above-named application.
6. I understand that the Examiner alleges, in the Office Action, that it would have been obvious to modify the apparatus taught by U.S. Patent No. 6,074,518 to Imafuku et al. (Imafuku) to incorporate the vertically arranged and movable confinement rings taught by U.S. Patent No. 6,019,060 to Lenz (Lenz) in order "to allow local control of the pressure at the substrate surface during plasma processing, and thereby, among other benefits, to improve response time."
7. I have reviewed Imafuku and Lenz.

8. I understand that Imafuku's magnets 72 and 74 form an annular local magnetic field between the circumferential edge portion of the upper electrode 21 and circumferential portion of the susceptor 5 so as to magnetically confine the plasma in the plasma generating region. I believe that Imafuku's magnetic fields are so designed that charged particles of the plasma are pushed back to the plasma generating region.

9. I understand that Lenz's plasma confinement rings with a cam-based arrangement provide a local control of the etch pressure in addition to its plasma confinement function. I also understand that such a local pressure control provided by the cam-based, movable confinement rings improves the response time, compared with a pressure control by varying the volume of the input etchant source gas or by increasing the pump-out rate of the byproduct gases, as stated in Lenz.

10. I do not think it would be obvious to combine the magnetic confinement of Imafuku with the local pressure control of Lenz to obtain the invention, as recited in the claims, for the following reasons.

11. I do not think it would be obvious to place the confinement rings of Lenz in a system with the magnetic confinement of Imafuku. My understanding is that Imafuku teaches that magnetic confinement is an alternative to physical confinement. As such, I believe that having both magnetic confinement and physical confinement, even to provide local pressure control, would be redundant. In addition one must take care to note the difference between physical confinement and confinement by magnetic and/or electric means. Imafuku presents a strictly magnetic approach, wherein the point of the magnetic fields is to retard plasma loss to the walls of this system. However, the invention is focused on physical confinement. The idea is to use a magnetic field to enhance loss to the confinement rings to enhance their physical confinement effect.

12. Even if a system had the confinement rings of Lenz and the magnetic confinement of Imafuku, I believe it would not be obvious to arrange the magnets and confinement rings so that magnetic field lines pass from the first magnetic element to the second magnetic element through the confinement ring, as recited in claim 2. In order to avoid any undesirable disturbance in the existing plasma confinement in Imafuku, those of ordinary skill in the art, I believe, would place Lenz's rings so as not to interfere with the magnetic fields generated by Imafuku's magnets. In addition, in the case of Imafuku, the arrangement of magnetic fields is intended only to reduce plasma losses and thereby

enhance confinement. It is contrary to the teaching of Imafuku to use an arrangement of magnetic fields in a way that would result in an enhanced plasma loss rate to a specific surface. By the teaching of Imafuku, it is not obvious that one would want to use an arrangement of magnetic fields to enhance plasma loss to the confinement rings.

13. Such an arrangement would be contrary to our invention in which the magnetic field lines pass through the confinement rings so as to enhance the physical confinement of the confinement rings. In our invention, the magnetic field is neither strong enough nor designed to confine the plasma by itself, but to cooperatively interact with the confinement rings by directing charged particles to collide with the confinement rings.

14. In our invention, the magnetic field modifies the trajectory of charged particles between the confinement rings, to redirect them into the confinement rings. For example, as described in the present specification, it is desirable to set the magnetic field such that charged particles have a Larmor radius nearly the same as the confinement ring width and of a radius intersecting a confinement ring. On the other hand, my understanding of Imafuku's magnetic fields for plasma confinement is that particles are to be re-directed back into the plasma volume rather than into a confinement ring or other wall surface in order to confine the plasma in the plasma generating region.

15. It must be remembered that physical confinement of plasma differs from magnetic confinement in that physical confinement is concerned with managing enhanced plasma loss to surfaces such that one may control the physical location of the plasma. Magnetic confinement concerned with control of the physical location of the plasma by managing reduced plasma loss to regions outside the desired plasma volume. Imafuku teaches that the magnetic field must be strong enough to re-direct particles back into the plasma we teach a method that does not need to achieve particle re-direction back into the plasma but rather redirection into confinement ring surfaces.

16. Accordingly, I believe that our invention would not be obvious under Imafuku in view of Lenz.

The undersigned declares further that all statements made herein of his own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under

§ 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing therefrom.

Dated: 10/8/2007 Signed: Douglas L. Keil
DOUGLAS L. KEIL